University of Glasgow

A2 Collaboration

Measuring the Polarisation Observables Using Recoil Polarisation

University of Glasgow's Nuclear Physics Group

Linearly Polarised Photons

Electrons passing through an amorphous Radiator will generally lose energy. The process we are interested in is known as *bremsstrahlung.* As an electron passes close to a positive core in the Radiator, it will emit electromagnetic energy in the form of a *bremsstrahlung* photon due to change in acceleration as the electron is deviated by the positive core.

When a crystalline structure is used instead of an amorphous structure in the Radiator, a different process occurs. Provided that the Radiator is aligned correctly, the electron will excite the aligned lattice plane and emit *coherent bremsstrahlung* at a specific energy range controlled by small rotations of the Goniometer.

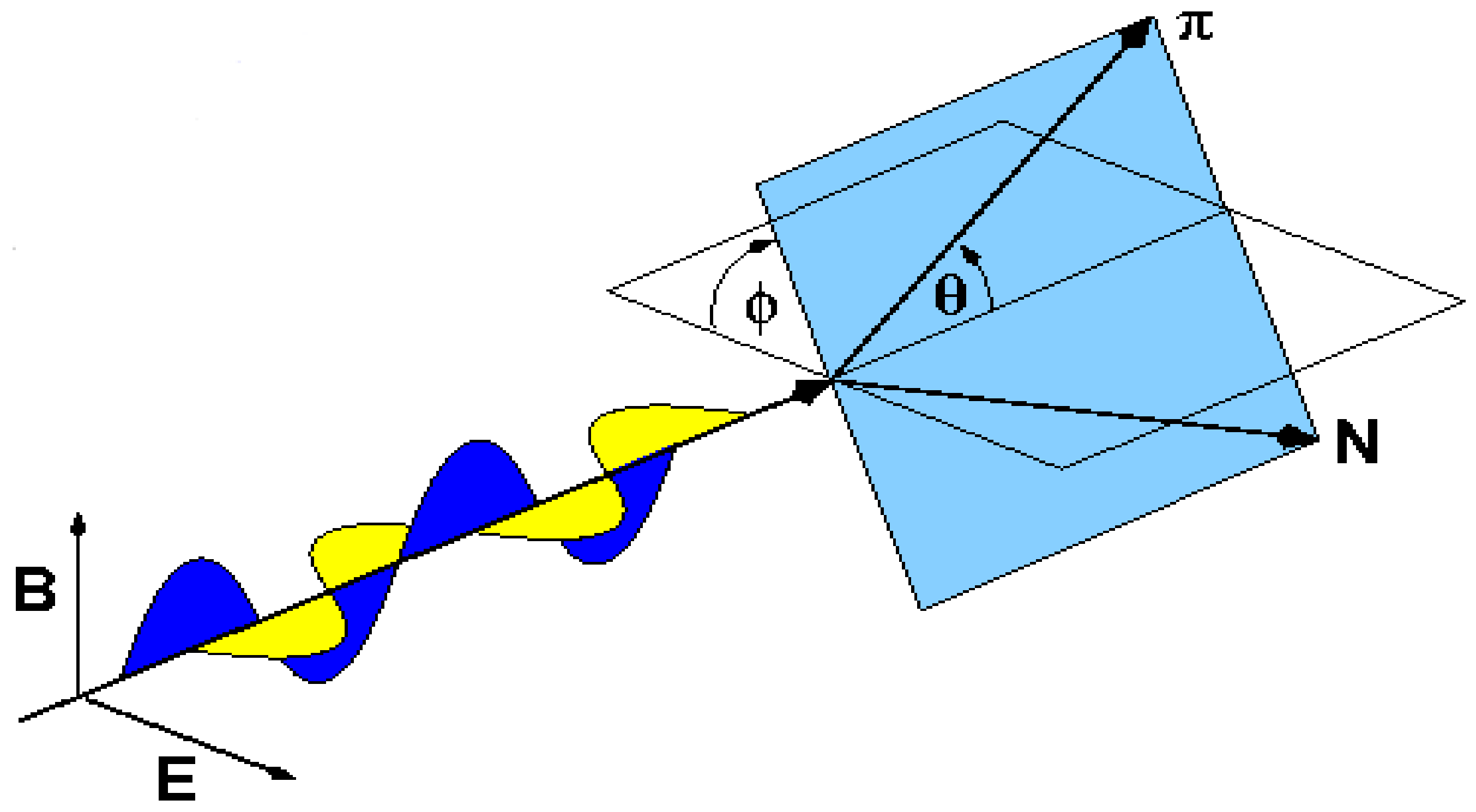

Fig 1. Vector Diagram showing a linearly polarised and the subsequent scattering plane

At the MAMI facility in Mainz – Germany, a Goniometer is used in order to make sensitive adjustments to the Diamond (Crystalline Radiator) and align the lattice planes. Once the electron beam passes the Goniometer, the electrons can be 'tagged' in a Photon Tagger, in order to determine the distribution of energy within the system. The Tagger is a large magnet and a large array of scintillators arranged in a focal plane. The magnet will bend the charged electrons into the focal plane, varying their angle of deviation dependent on how much energy they deposited when passing through the Diamond Radiator. The electrons deposited in the focal plane can be used to produce a spectra of these hits. The subsequent photon beam is passed through a collimator.

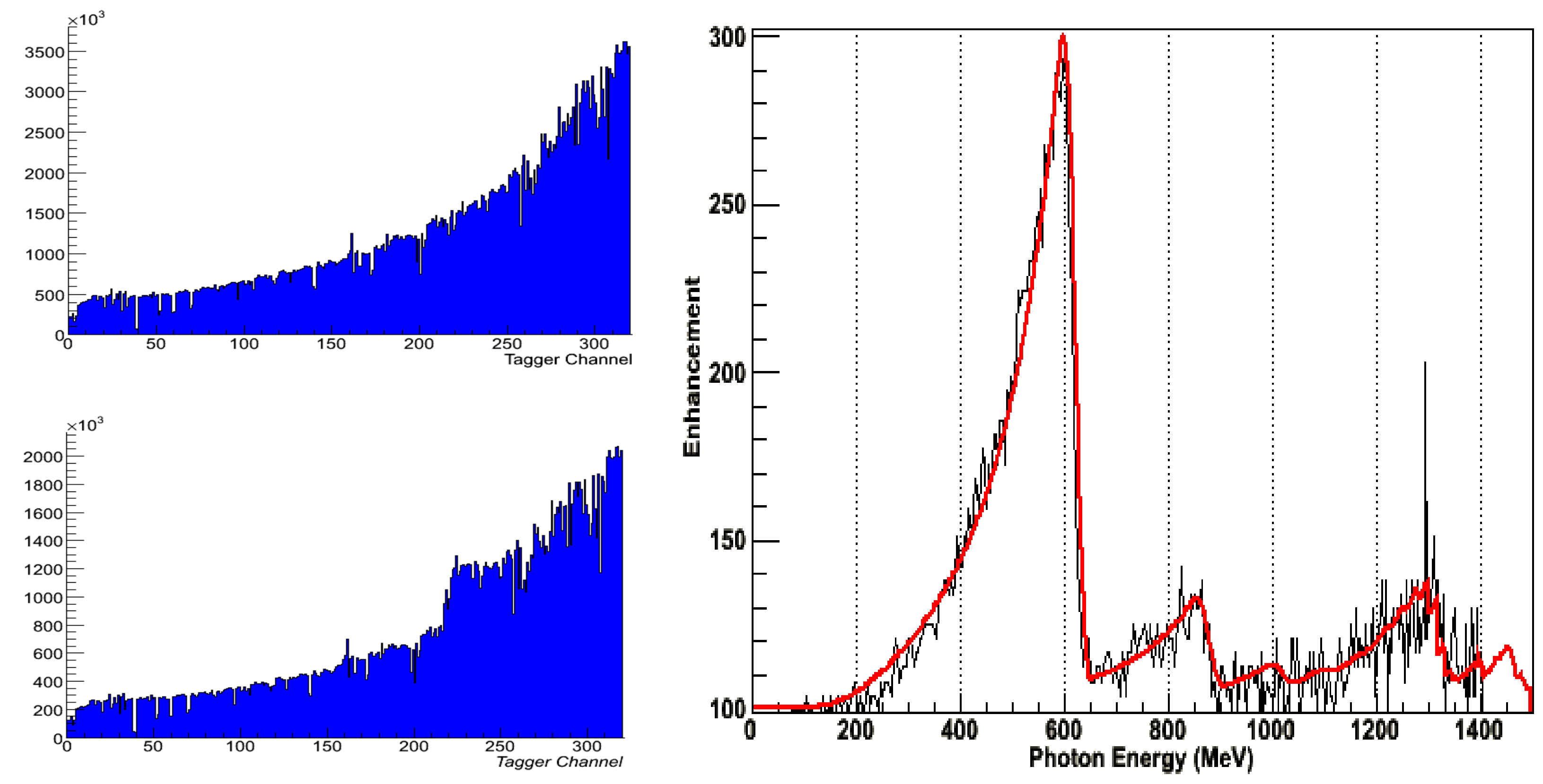

Fig 2. Amorphous and Polarised Tagger Spectra (Left) and a Photon Energy Enhancement (Right; Amorphous contribution divided out from Polarised) and Fit showing the Coherent Peak

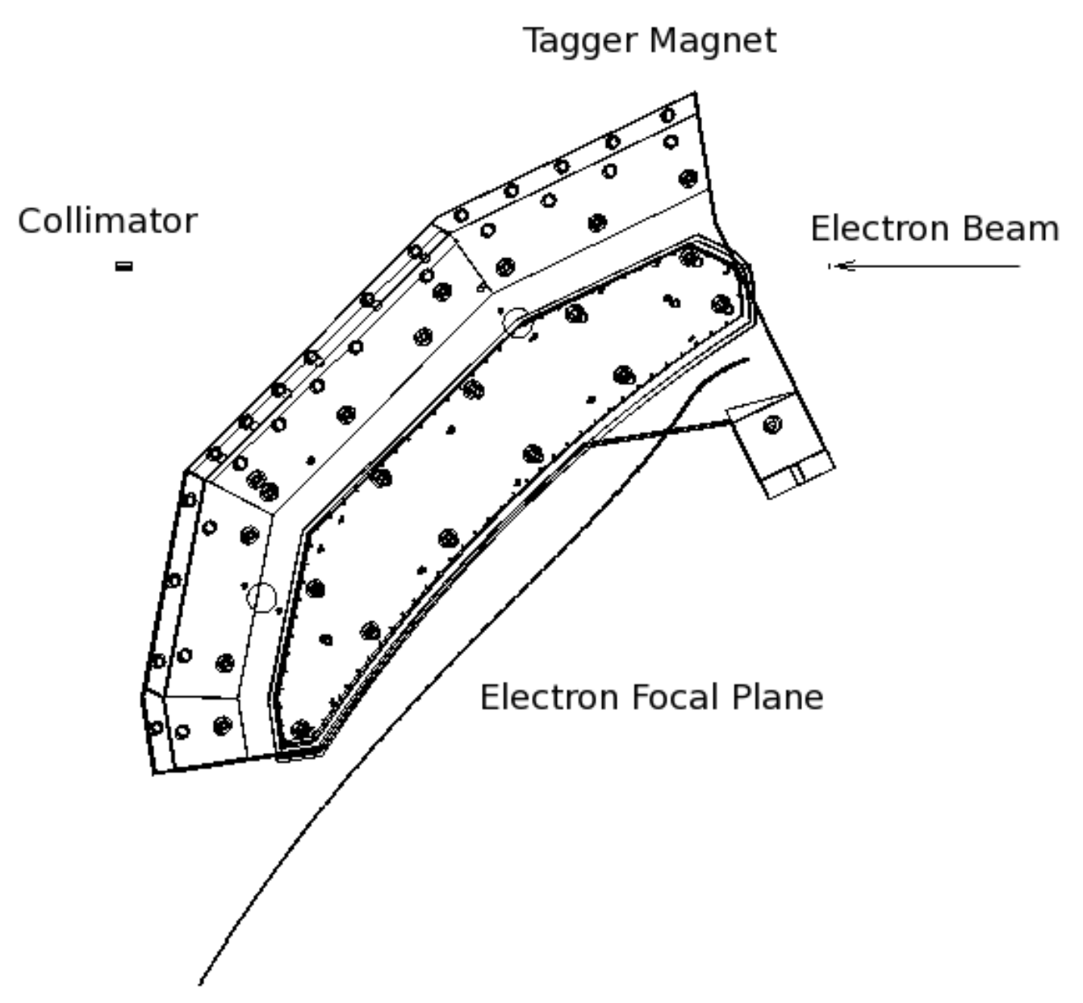

Fig 3. Tagger Magnet and Focal Plane from Geant4 Simulation

Recoil Polarimetry

Recoil Polarimetry is key to measuring certain Polarisation Observables. Using a Carbon Polarimeter in the experimental setup we can cause recoil particles recoil. When a particle product of a reaction passes through the polarimeter, it can scatter on a nucleus within. This gives a preferred orientation of its spin, or a polarization. This factor can then be used to measure Observables.

Careful event selection is needed for this process as scattering can occur through other mechanisms of less interest for these observables ie. Simple Coulomb rather than the Strong Nuclear Interactions.

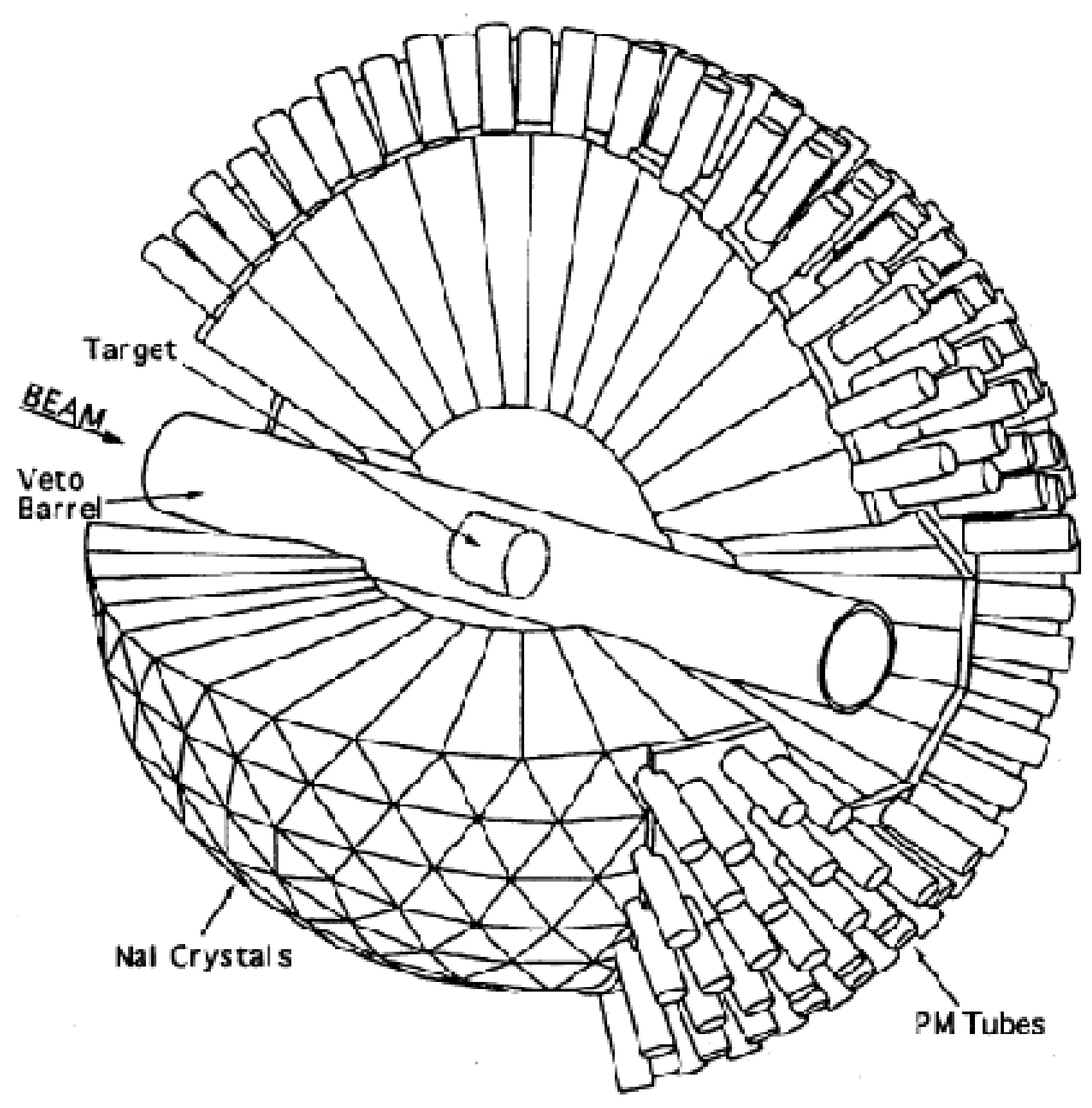

Fig 3. Schema of the Crystal Ball Detector. The Carbon Polarimeter sits around the Veto Barrel as well as a plug for the exit hole

The Observables

Polarisation observables are a further insight into the properties and structure of the nucleus. Using the measurement of these observables, we can gain a better handle and perhaps broader scope on several things, however most notably, the missing baryon resonances predicted in the quark model.

Polarisation observables are obtained using particles that carry polarisation in experiment (Namely beam photons and target nuclei). Using the data taken at MAMI, it is proposed to measure the Beam Recoil Observable O_x and the Asymmetry Σ.

Observable.	Polarisation
σ, Σ, P, T	Single
E, F, G, H	Double: Beam - Target
O, C, T, L	Double: Beam – Recoil/Target - Recoil

Table 1. Polarisation Observables

The Experiment

The Data was taken with a constant circular polarisation and a majority of it included linear polarisation also, for the measurement of O_x (The Circular was taken for the measurement of C_x). As mentioned above, event selection is very important, and so a great deal of time must be taken over separating recoiling and non-recoiling protons.

As seen in figure 5, clean proton events can be reconstructed from the detected π^0. These events will be used as a non-recoil reference, and when mapping the detected protons, we can check the angular offset from the reconstructed event to ensure we select recoiling events only.

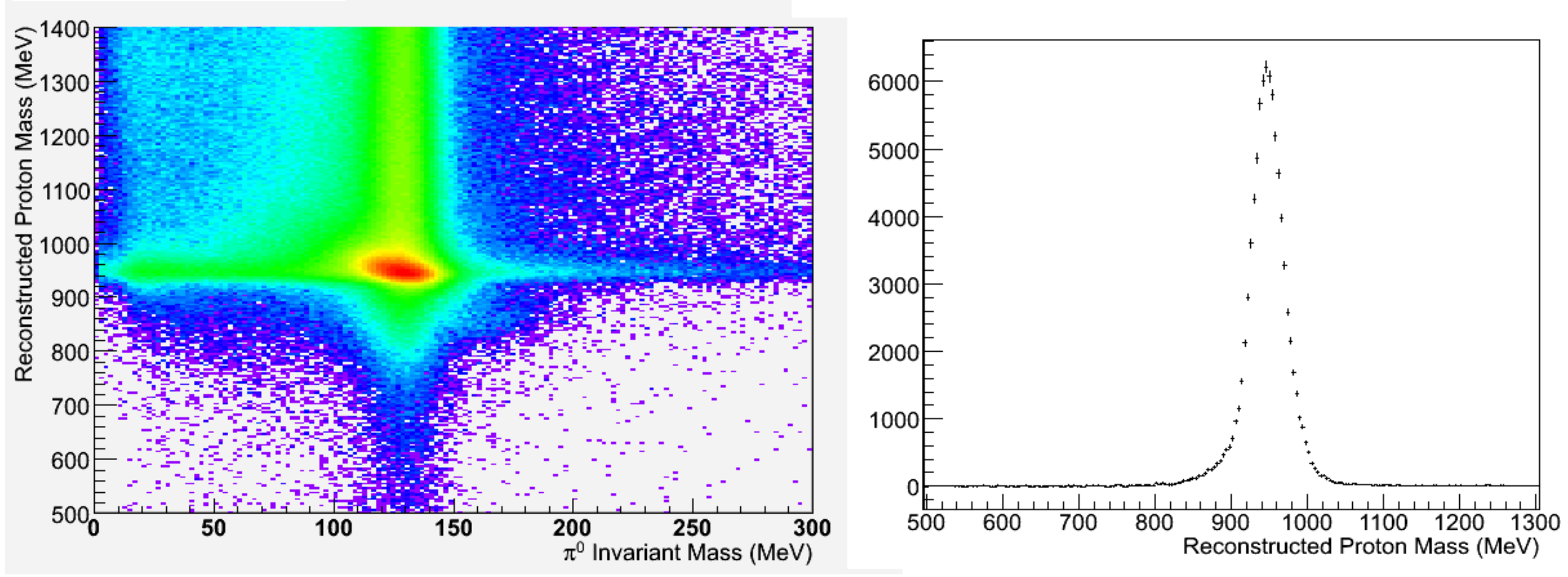

Fig 5. Plot of the π^0 Invariant Mass against Reconstructed Proton Mass, and the Reconstructed Proton Mass on its own.

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